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INVENTOR-INFORMATION:

NAME	COUNTRY
HINTON, THOMAS MARC	N/A

ASSIGNEE-INFORMATION:

NAME	COUNTRY
HINTON THOMAS MARC	N/A

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ABSTRACT:

The engine has two rotor chambers 202 and (202%), Fig. 2 (not shown), wherein the induction and compression phases and the expansion and exhaust phases of the working cycle are performed, respectively. Each rotor 206, 206% may have a single lobe or "bulge" that sweeps the peripheral wall of the respective chamber and may co- operate with a pivotally mounted vane or "sealing arm" 230, (230%), the rotor of the first chamber being driven by the rotor of the second chamber. The chambers may be disposed co-axially with the rotors mounted on a common shaft (260). The sealing arms may be held in contact with the rotors by cams 280, 280%. Compressed fuel-air mixture may be transferred from one chamber to the other through a port 222. Ignition may be initiated in the second chamber by a sparking plug (not shown). <IMAGE>

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(71) Applicant
Thomas Marc Hinton,
1 Courtleigh Close,
Westbury, Wiltshire

(72) Inventor
Thomas Marc Hinton

(74) Agent and/or Address for Service
Mewburn Ellis and Co.,
2—3 Cursitor Street,
London EC4A 1BQ

(54) Rotary internal-combustion engine

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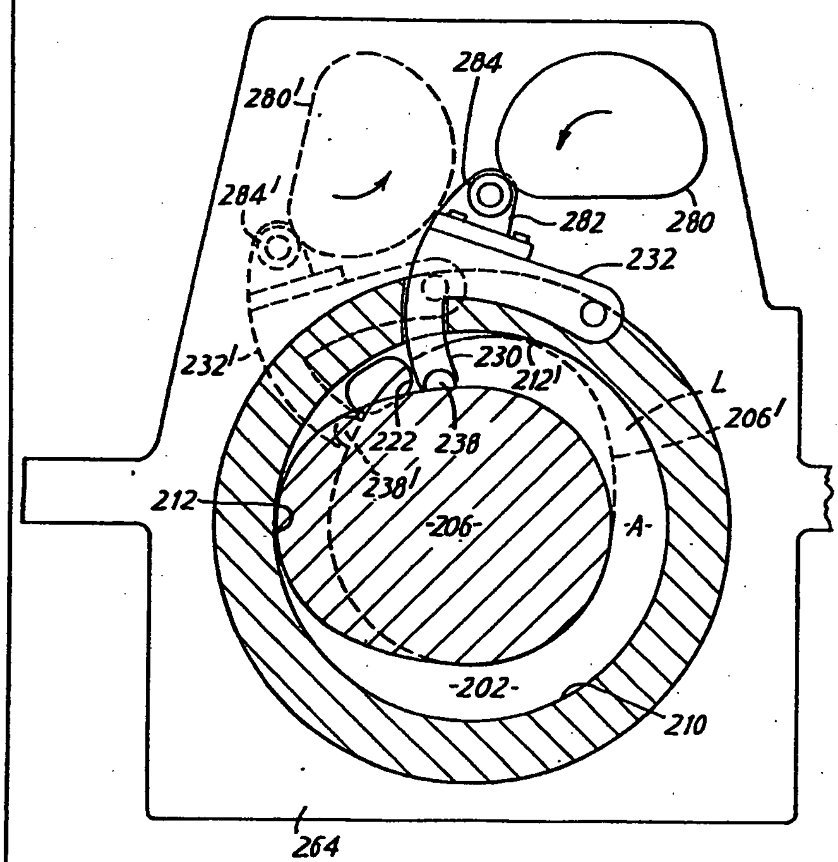

FIG.3

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FIG.1 (SHEET i/iii)

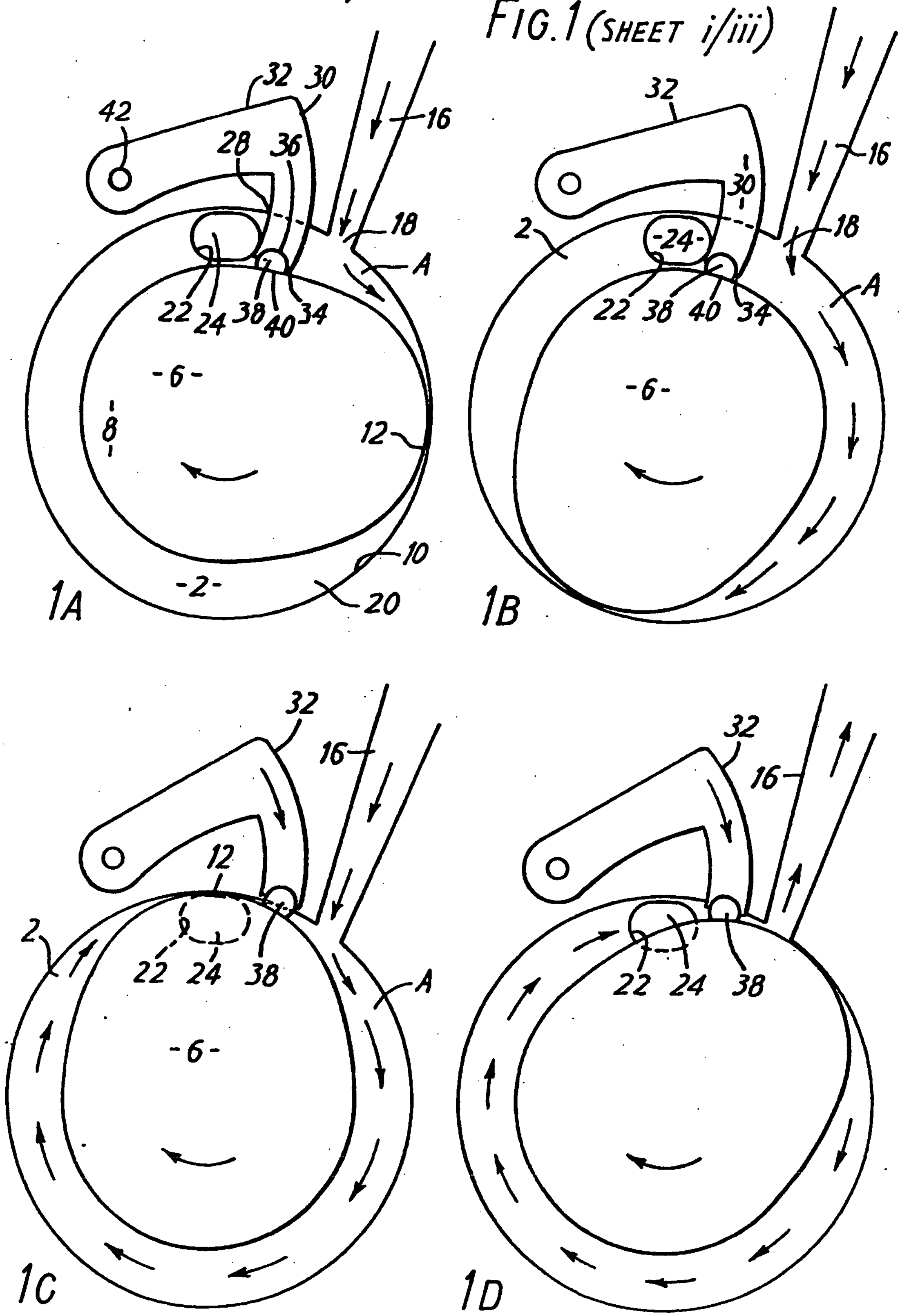


FIG.1 (SHEET ii/iii)

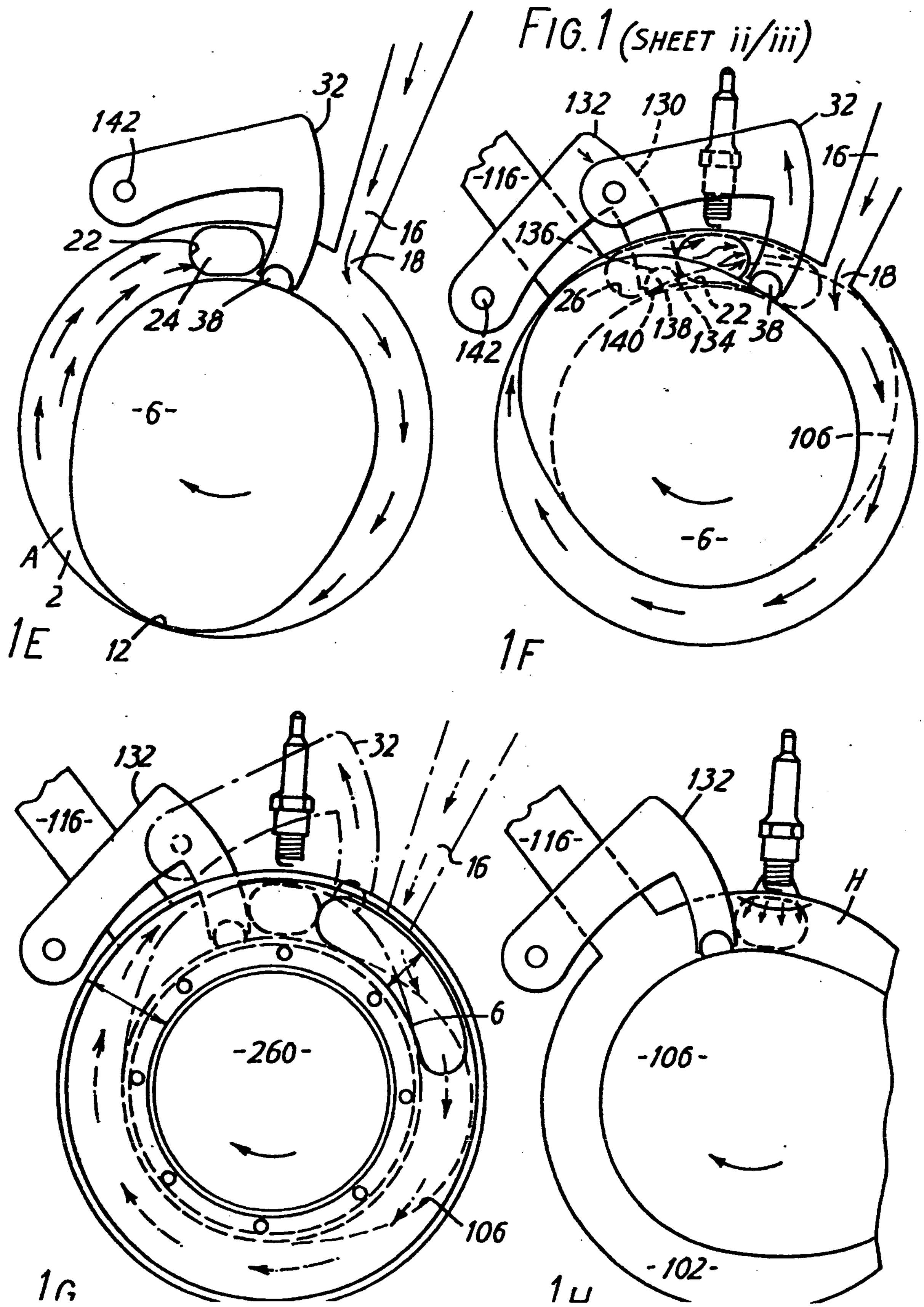
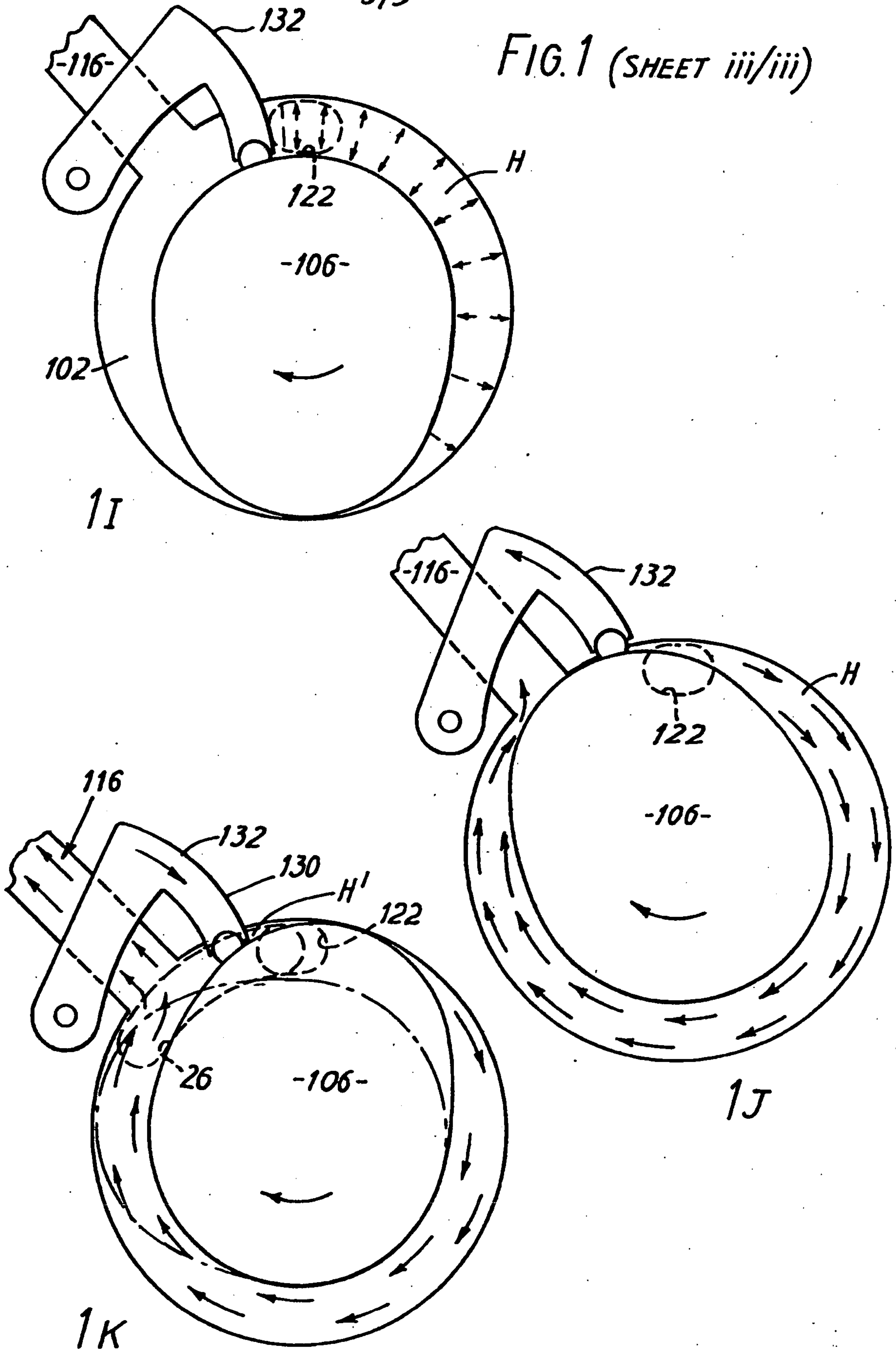


FIG.1 (SHEET iii/iii)



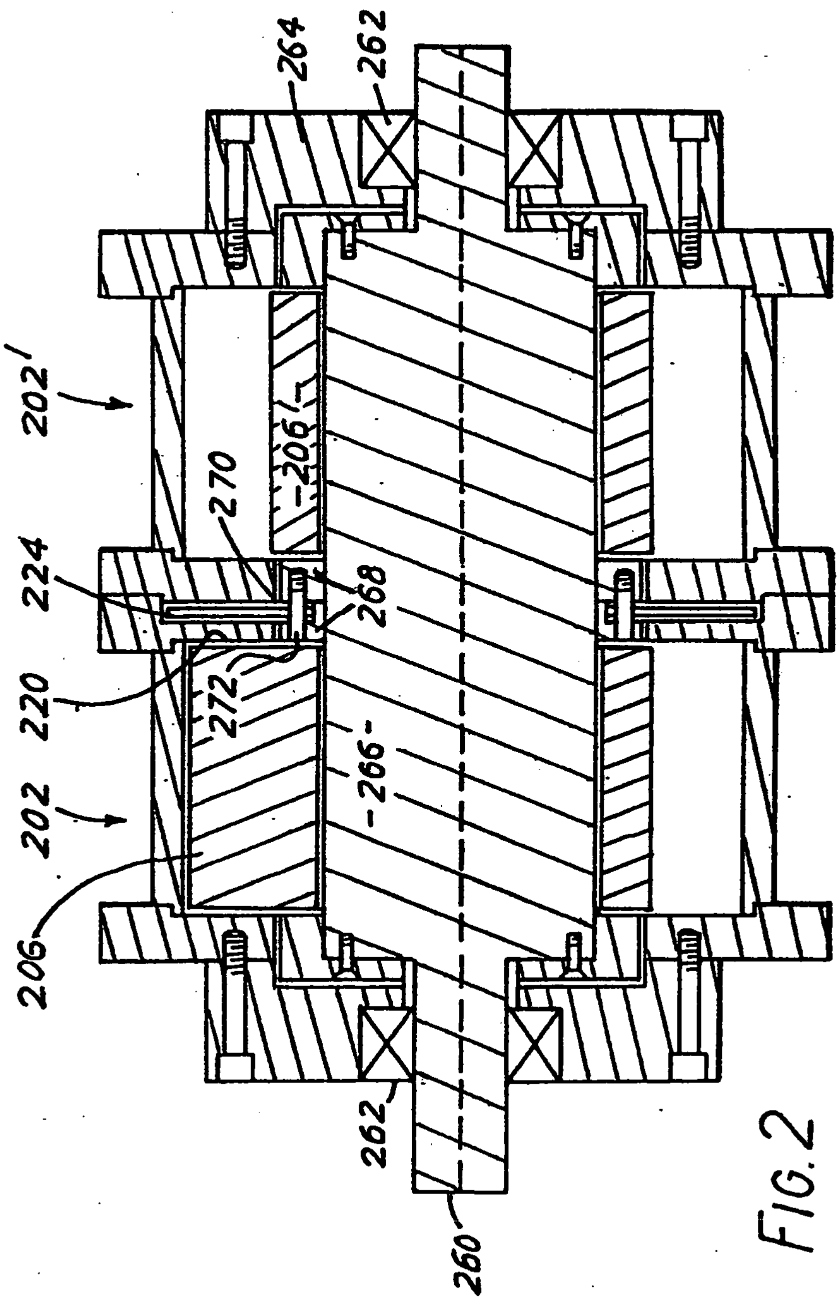


FIG. 2

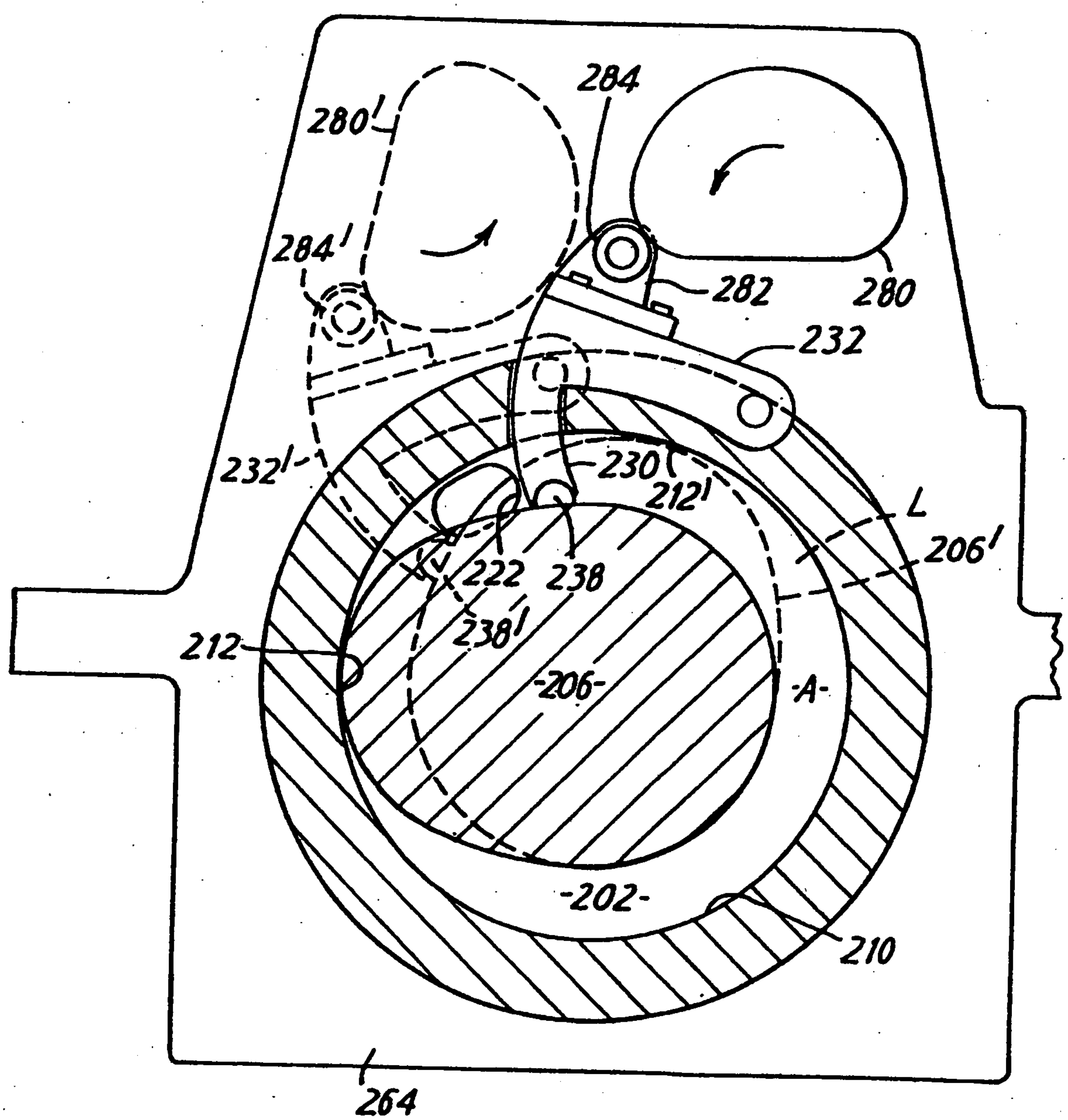

280'
284
284'
282
280
232
232'
230
212'
L
206'
222
238
238'
212
-206-
-A-
-202-
210
264

FIG.3

SPECIFICATION

Rotary internal combustion engine

The present invention relates to internal combustion (IC) engines, and particularly to rotary IC engines.

Despite the great success of reciprocating piston IC engines, they have many defects. A conventional engine cylinder produces power only in a 'power stroke', which is at most only $\frac{1}{2}$ or $\frac{1}{4}$ of the operating cycle. Furthermore the power is produced as linear reciprocatory motion, whereas it is required as rotatory motion. The means used for converting the motion (connecting rod, crankshaft etc.) are inherently inefficient. They cause uneven torque transmission, since the effective lever length via which the piston turns the crankshaft varies throughout the stroke.

Several attempts have been made to avoid or reduce these problems. A radical approach is to abandon reciprocating cylinders in favour of some system in which rotatory motion is produced more directly. Probably the only rotary IC engine which has had any real commercial success is the Wankel engine — and even this has tended to remain a novelty. It has certainly made no substantial inroads on the dominance of conventional piston IC engines.

At least part of the reason for the lack of success of rotary IC engines may lie in their complexity of design. Thus the Wankel engine employs a rotor and housing of complex shapes. The housing's internal cross-section is an epitrochoid, with openings to serve as inlet and outlet ports and for mounting a spark-plug. The rotor is an eccentrically-mounted equilateral triangle having convexly curved faces with a depression in the centre of each. Three chambers are thus provided between the housing and respective faces of the rotor. They are sealed by seals provided on the rotor, at the vertices and at the sides of each face. In one rotation of the piston, each chamber goes through two complete cycles of volume change, and a four-stroke cycle is performed.

The advantages of such an engine over a conventional IC engine are its essential simplicity (there are few moving parts, for connecting rods, valves and their operating gear are eliminated and peripheral ports can be permanently open); and the potential smoothness of running (the absence of reciprocation should allow the engine to be well balanced, so it can operate at high speed with low vibration). However, the essential simplicity is impaired by such features as the rather elaborate seals. Indeed, the seals and wear of the chamber have been major problems of rotary engines. Other problems or inconveniences to which the Wankel engine is prone are associated with the difficulty of cooling a rotor which attains a high temperature three times per cycle, and the risk of chamber distortion due to the proximity of the cool inlet and the hot outlet.

According to the present invention there is provided a rotary engine having: an induction chamber and a power chamber, each chamber having a relatively rotatable rotor; and means for selectively permitting and preventing communication from the induction chamber to the power chamber; and wherein the induction chamber is arranged for the performance of induction and compression, and the power chamber is arranged for the performance of power production (using material induced and compressed in the induction chamber) and exhaustion.

Preferably the chambers are cylindrical.

Preferably the induction and power chambers are coaxial. The rotors may then be mounted on a common axial shaft which may also carry disc valve means for controlling said communication.

Preferably a single rotation of the rotors corresponds to a single working cycle of the engine.

Preferably each rotor is arranged to contact the periphery of its chamber sealingly at a region substantially fixed relative to the rotor, and there are means cooperating with the rotor at a substantially fixed angular region of the chamber to partition the volume of the chamber. The partitioning means may be a cam gate which extends sealingly and displaceably through the peripheral wall of the chamber, and sealingly contacts the peripheral surface of the rotor.

An embodiment of the invention will now be described in greater detail with reference to the accompanying drawings, in which:

Figs. 1A—1K are schematic radial sections for describing the operating cycle of an engine embodying the invention;

Fig. 2 is an axial section through the chamber assembly of an engine embodying the invention; and

Fig. 3 is a radia: section through the power chamber of the engine of Fig. 2 showing the cam gate restraint means.

Referring first to Fig. 1, the engine shown schematically therein has two coaxial cylindrical chambers: an induction chamber 2 and a power chamber 102. Each contains a respective coaxial rotor 6, 106 on a common driveshaft. Each rotor has a peripheral cam surface which is in part (8, 108) generally concentric with the peripheral wall 10, 110 of the chamber (and spaced from it), but which at one region 12, 112 approaches the wall 10, 110 and ideally contacts it slidably and so as to provide a seal. As shown, the direction of rotation is clockwise. The induction chamber 2 has an induction inlet 16 which opens at a port 18 in the wall 10. The inner axial end wall 20 of the induction chamber 2 i.e. the wall adjacent the power chamber 102 has a transfer port 22 at an outer region of the wall 20, such that it is not coverable by the concentric part 8 of the rotor 6. Its angular location is about 30° before the inlet port 18 (centre to centre), and it extends over about 20°. The port 22 communicates via a paraxial conduit with a like port in the power chamber 102. A disc valve 24 is located between the chambers 2, 102, mounted for rotation with

the driveshaft. At one sector it has an elongate arcuate opening 26 radially coincident with the transfer ports 22, 122. Thus communication between the ports is possible only during that part of the cycle in which the slot 26 is at least partly in register with them.

Angularly between the transfer port 22 and the induction port 18, the peripheral wall 10 of the chamber 2 is penetrated by an axial slot 28. The sealing arm 30 of a generally L-shaped cam gate 32 extends slidingly and sealingly through it. The end face 34 of the arm 30 has an elongate axial recess 36 which is part-circular in section. A follower-seal 38 is correspondingly formed so as to seat rotatably and sealingly in the recess 36. Its following face 40 is concave in section, adapted so that it can rest substantially sealingly on the rotor 6 in any rotational configuration thereof. The cam gate 32 is mounted on a pivot pin 42 so that it can pivot to allow the follower-seal 38 to follow the cam surface of the rotor 6.

As may be seen from Fig. 1G, the power chamber 102 is very similar to the induction chamber 2, and corresponding elements are referred to by the same reference number but raised by 100. An important difference is the presence of a spark chamber 150 in the chamber wall 110, at the angular position of the transfer port 122. A sparking plug 152 is fitted thereto.

As is the case with the induction chamber, the power chamber has a cam gate assembly (130—142) located before the transfer port 122 and, further anticlockwise, there is a peripheral port 118. This is the exhaust port 118, and is somewhat larger than the induction port 18. It leads to an exhaust outlet 116.

The operation of the engine shown in Fig. 1 will now be described. It will be convenient to speak in terms of various phases, but it will be understood that more than one phase is happening simultaneously in different regions.

Figs. 1A to 1E show only the induction chambers. In Fig. 1A, the transfer port 22 is closed by the disc valve, and the contact region 12 of the rotor is at the 3 o'clock position. A first induction phase is starting in the chamber portion A defined adjacent the induction port 18 by the peripheral walls of the rotor and chamber and the sealing arm 30. (Chamber portion A does not refer to a fixed portion of the chamber 2.) The rotor moves to increase the volume of chamber portion A and thus draw a combustible mixture through the inlet 16, as seen in the successive Figs. 1B and 1C. Once the rotor's contact region 12 has passed the induction port 18 (Fig. 1D), the compression phase starts. (Of course, a second induction phase begins simultaneously. Thus Figs. 1B and 1E are really the same.) From a point when the contact region 12 is slightly before the 9 o'clock position, the slot 26 in the disc valve begins to transverse the transfer port 22. Thus the transfer conduit opens. Fig. 1F shows the induction rotor 6 in full lines and the power rotor 106 in broken lines at a stage when the transfer ports 22, 122 are fully open. (The valve slot 26 is also shown in broken lines.) Fig. 1G can be regarded as a section through the disc valve 24, with the induction rotor 6 shown in chain dotted lines and the power rotor 106 shown in broken lines. Fig. 1H is a simultaneous view showing only the power chamber and rotor. The valve slot 26 has just reached a position such that the transfer ports 22, 122 are closed, and the sparking plug 152 has just fired to ignite the mixture in a closed chamber portion H (see Fig. 1H) which is defined, like portion A in Fig. 1A, by the peripheral walls of the rotor 106 and chamber 102 and the sealing arm 130. As can be seen from Fig. 1G, the induction rotor 6 is at the 12 o'clock position (so that the second induction phase is nearly complete), and the power rotor 106 is approximately 97° ahead of it. The combustion gases expand, and drive the rotor 106, and of course the coupled elements such as the induction rotor 6 and the disc valve 24. Fig. 1I shows the power chamber after 90° of power revolution. Fig. 1J shows how, after about 215 or 220° of useful power revolution the chamber portion L extends to the exhaust outlet 116, and the combustion gases begin to pass out.

Fig. 1K shows the power rotor 106 at a position where it is just uncovering the transfer port 122. Ahead of its contact region 112 it is sweeping out the exhaust gases. A new chamber portion H' is growing, bounded by the surfaces of the rotor and the chamber and by the sealing arm 130. The transfer port is opening (the disc valve slot 26 is shown in broken lines), and the charge of compressed vapour produced by the second induction phase is being forced therethrough. In the induction chamber 2 a third induction phase has completed 260° (the induction rotor 6 is shown in chain-dotted lines). Note that exhaustion from the power chamber occurs continuously over almost the entire operating cycle.

Figs. 2 and 3 show a practical embodiment of an engine employing the operating principles just described. Elements corresponding to those described with reference to Fig. 1 are generally given corresponding reference numbers in the 200 series with elements associated with the power chamber primed (as, 200').

Fig. 2 shows a vertical axial section through the engine. An axially-extending driveshaft 260 is journalled in bearings 262 in a housing 264. The part 266 of the shaft 260 which extends through the chambers 202, 202' is of increased diameter, and the rotors 206, 206' are mounted on it so as to be rotationally just (e.g. by splining). A portion of the shaft 260 intermediate the chambers is provided with two annular portions 268 of greater (and equal) height, axially spaced so as to define an annular channel 270, in which the disc valve element 224 (which is actually annular) is located, and retained by screw-bolts 272 passing paraxially through threaded bores in the annular portions 268.

It will be understood that the timing of the operating cycle is dependent on the angular extends of the transfer ports and the slot in the disc valve, and on the relative angular positions of

the various elements notably the two rotors, the ports, and the valve slot. The diagrams of Fig. 1 show reasonably accurately a presently preferred configuration, which is used in the embodiment of Figs. 2 and 3. A feature which is believed to be particularly desirable is the long power stroke. The power rotor is driven through about 220°. The rotor 206' from its axis to its contact region 212 acts as a lever, of constant length, which extracts power from the explosion with high efficiency over the long power stroke. (Contrast the low and inconstant efficiency of a reciprocating IC engine in which the effective lever length of the connecting rod is always varying, and the small angle available in the Wankel engine for power extraction.)

The engine shown in Figs. 2 and 3 is intended to run on two-stroke oil/petrol mixture to provide lubrication of the seals and the disc valve.

The cam gates 232, 232' have the same basic form as those shown in Fig. 1, with following seals 238, 238' adapted to follow the cam surfaces of the rotors. In order to prevent them from flying off the rotor surfaces, some form of restraint is desirable. Of course, springs could be employed. But these are not preferred because of their general unreliability and tendency to cause repercussion. Instead, a system of counter-cams is used, as shown in Fig. 3.

Thus, associated with each cam gate (e.g. 232) there is a counter-cam (e.g. 280) rotationally coupled to the driveshaft 260 and having peripheral cam surface 282 which is complementary to the associated rotor 206. The cam gate 238 has on its rear side a pair of axially spaced projections 282, generally behind the sealing arm 230. (The radially outer surfaces of the arm 230 and projection 282 define a common arc.) A cam follower roller 284 is pivotally mounted on a pin mounted between the projections 282. The system is arranged so that the cam gate 232 is in contact with both the rotor 206 (with its following seal 238) and the counter-cam 280 (with its roller 284). The form of the cam 280 is so matched to that of the rotor 206 that this contact is preserved throughout their rotation.

In order to allow for manufacturing tolerances and the effects of uneven wear, and to provide cushioning, the mounting of the follower rollers to the cam gates may incorporate shock absorbing means. Compressed rubber pads may be used, e.g. between the projections 282, 282' and the sealing arms 230, 230'.

The preferred embodiment of the present invention can give the advantages of a Wankel engine, without many of its disadvantages. Thus, the absence of reciprocating pistons can allow high speed operation with minimal vibration or balancing problems. The fact that the induction and exhaust ports are always open leads to considerable simplification and avoidance of many problems of conventional engines. The volumetric efficiency can be very high compared with Wankel-type engines, the fact that the chambers are simply cylindrical in form and the rotors are not complex makes manufacture simpler. The division of the engine functions between two chambers avoids the problems associated with the proximity of the induction and exhaust ports. The fact that one rotation of the power rotor corresponds to one power phase (and not three) reduces theremal stresses, and allows excellent efficiency of power extraction.

Of course, the illustrated embodiment is given only by way of example, and much variation is possible. For example, an engine could be arranged to perform more than one power phase per revolution, by having corresponding numbers of ports and sparking plugs. (This is not at present preferred, however, since it loses the advantage of the longer power stroke).

CLAIMS

1. A rotary engine having: an induction chamber and a power chamber, each chamber having a relatively rotatable rotor; and means for selectively permitting and preventing communication from the induction chamber to the power chamber; and wherein the induction chamber is arranged for the performance of induction and compression, and the power chamber is arranged for the performance of power production (using material induced and compressed in the induction chamber) and exhaustion.

2. A rotary engine according to claim 1 wherein the induction and power chambers are generally circular in cross-section and coaxial, and the rotors are mounted on a common axial shaft.

3. A rotary engine according to claim 2 wherein said common shaft carries disc valve means for controlling said communication.

4. A rotary engine according to claim 3 wherein said chambers have respective transfer ports in adjacent axial end walls and said disc valve means comprises an apertured element arranged so that said cylinders are communicable via the transfer ports and the aperture in the valve element only in a predetermined range of angular positions of the element.

5. A rotary engine according to any one of the preceding claims wherein each rotor is arranged to contact the periphery of its chamber sealingly at a region substantially fixed relative to the rotor, and there are means cooperating with the rotor at a substantially fixed angular region of the chamber to partition the volume of the chamber.

6. A rotary engine according to claim 5 wherein the partitioning means comprises a cam gate which extends sealingly and displaceably through the peripheral wall of the chamber, and sealingly contacts the peripheral surface of the rotor.

7. A rotary engine according to claim 6 wherein the displacement of each cam gate is limited by a respective cam which is shaped complementary to the associated rotor and driven in synchronism with it.

8. A rotary engine according to any one of the preceding claims wherein the induction chamber has an induction port and the power chamber has

an exhaust port, and the rotation of the respective pistons is arranged to effect the opening and closing of these ports.

9. A rotary engine according to claim 8 wherein the induction and exhaust ports are so arranged that each is open to effect induction and exhaust (respectively) over a substantial part of the operating cycle.

10. A rotary engine according to any one of the preceding claims wherein a single rotation of the rotors corresponds to a single working cycle of the engine.

11. A rotary engine substantially as described herein with reference to and as illustrated in the accompanying drawings.

12. A chamber assembly comprising induction and power chambers for use in a rotary engine according to any of the preceding claims.

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